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## Original Article

## Validating the Persian Adolescent Sleep Hygiene Scale-Revised (ASHSr) using comprehensive psychometric testing methods

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## ABSTRACT

**Background:** This study translated the Adolescent Sleep Hygiene Scale-revised (ASHSr) into Persian and aimed to validate its psychometric properties using classical test theory and Rasch analyses.**Methods:** Adolescents aged 14–18 ( $n = 389$ ; 199 males) and their parents in Iran participated in the study. Each adolescent wore a wrist actigraphy device during sleep time and completed the ASHSr, the Depression Anxiety Stress Scale (DASS), the General Health Questionnaire (GHQ), the Pediatric Daytime Sleepiness Scale (PDSS), and the Pittsburgh Sleep Quality Index (PSQI). A parent of each adolescent completed the Sleep Disturbance Scale for Children (SDSC).**Results:** The construct validity of the ASHSr was supported by both classical test theory (factor loadings from confirmatory factor analysis [CFA] = 0.64 to 0.88; corrected item-total correlations = 0.70 to 0.92; test-retest reliability = 0.72 to 0.90) and Rasch analyses (infit mean square = 0.73 to 1.30; outfit mean square = 0.74 to 1.32). ASHSr had significantly negative associations with DASS subscales ( $\beta = -0.15$  to  $-0.42$ ,  $ps < 0.001$ ) and GHQ ( $\beta = -0.663$ ,  $p < 0.001$ ). Known-group validity was demonstrated by the significant differences between poor and good sleep hygiene based on ASHSr in the actigraphy measure and scores of PDSS, PSQI, and SDSC. The multigroup CFA and differential item functioning in Rasch analyses suggested that all the participants interpreted the ASHSr similarly, regardless of their gender or living in a private room.**Conclusions:** The Persian ASHSr demonstrated good reliability and validity in assessing sleep hygiene among Iranian adolescents. Healthcare providers may use it to assess the effectiveness of sleep hygiene programs.

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## 1. Introduction

There are increasing concerns about sleep disturbances among adolescents as electronic media use, and online gaming, become increasingly prevalent [1–3]. Stress may be associated with such sleep disturbances [4], which consequently result in poor physical and mental health outcomes [5]. Several countries have documented an increasing trend in various sleep problems or poor sleep behavior in adolescents [6,7]. Studies have shown an increase in insomnia symptoms in Finnish adolescents from 1984 to 2011 [7], sleep-onset

difficulties among Norwegian adolescents from 1985 to 2005 [8], and a decrease in sleep duration in U.S. adolescents [6]. Sleep problems are also frequent among Iranian children; a recent report found that nearly half of 300 children who attended a sick visit or routine growth control had one or more sleep problems [9]. Moreover, Chelri et al. reported that Iranian adolescents had considerably poorer sleep hygiene behaviors than did their US counterparts [10]. Considering that sleep deprivation and poor sleep quality often are associated and can develop into habitual behaviors with negative outcomes, a detailed examination of sleep hygiene behavior should not be overlooked even among adolescents.

Good sleep hygiene in adolescents (eg, avoiding drinks with caffeine, excess water before bedtime and activities that keep people awake) is a major factor associated with earlier bedtimes,

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shortened sleep latency, longer sleep length [11] and better sleep quality [12,13]. For example, a recent study showed that in a sample of 15–17-year-old New Zealand adolescents, a strong association exists between the Adolescent Sleep Hygiene Scale (ASHS) and sleep quality [12]. Regarding gender difference, girls in the New Zealand study had poorer sleep hygiene than boys, especially in constructs of behavioral arousal, cognitive/emotional, and sleep stability [12]. Socioeconomic status (SES) is another factor associated with sleep pattern in adolescents [14]. Although no direct evidence showing that adolescents from lower SES have worse sleep hygiene practices, both sleep hygiene practices and SES have been found to be associated with sleep patterns [14].

Given the importance of sleep hygiene, validated tools to measure sleep hygiene are essential for healthcare providers to understand how an individual sleeps and to provide timely intervention if necessary. One of the most frequently used measures is the ASHS, revised from the Children's Sleep Hygiene Scale developed in 2005 by LeBourgeois et al., [13]. The ASHS has been applied to various populations, such as adolescents with physical and psychiatric comorbidities in the U.S. [15] and with autism spectrum disorders in the U.S. [16]. A 2014 study by de Bruin, van Kampen, van Kooten, and Meijer examined the psychometric properties and clinical relevance of the ASHS in a sample of Dutch adolescents [17]. ASHS scores were compared between normal sleepers and those with insomnia, establishing the validity of sleep hygiene in insomniac adolescents [17].

A revised version of ASHS, known as ASHSr, has been validated in a U.S. adolescent sample via confirmatory factor analysis and concurrent validity. The concurrent validity was shown by the high correlation between the ASHSr and objective measures of sleep quality and behavior (ie, actigraphy), as well as with behavioral outcomes (ie, Child Behavioral Check List) [18]. Given that the ASHSr is shorter than the ASHS, the ASHSr may be more practical than the ASHS. However, studies that have aimed to validate the psychometric property of this scale when applied in a different culture are scarce. While there is a significant impact of sleep hygiene on adolescents and the application of developing interventions (eg, cognitive-behavioral approach, health action process approach) is becoming more prevalent [19,20], more studies are needed to validate sleep hygiene measurement in various contexts and populations.

Recently, a group of Iranian researchers validated the Persian ASHSr among 1013 adolescents [10]. They tested the ASHSr for its factorial structure using confirmatory factor analysis (CFA), for its internal consistency using Cronbach's  $\alpha$ , for its concurrent validity with the Pittsburgh Sleep Quality Index (PSQI) and for its test-retest reliability with a six week interval using Pearson correlations. Their results showed that the Persian ASHSr is reliable and valid. Although psychometric evidence was examined, we considered that additional psychometric information about the Persian ASHSr is needed. For example, Chehri et al., did not use psychometric testing applying modern test theory (eg, Rasch analysis), did not examine whether different groups (eg, boys vs. girls) interpret the ASHSr items differently, and did not use an objective instrument to validate concurrent validity [10]. As a result, we proposed to comprehensively examine the Persian ASHSr again.

In this study, we validated the psychometric properties of the ASHSr at both item and domain levels using two approaches: classical test theory and Rasch analysis. A surge of interest in using Rasch analysis in validating sleep-related scales is apparent in the recent literature [21,22], indicating that solely using classical test theory may be limited for analyzing and presenting psychometric properties. To the best of our knowledge, no studies have applied Rasch analysis to the ASHSr. Therefore, testing ASHSr using Rasch models is warranted and is likely to provide additional valuable

information about the ASHSr. We also validated the concurrent validity of ASHSr with mental health and general health outcomes in adolescents.

Furthermore, to ensure the same construct is being measured across gender and socioeconomic status, indicated by living condition, we conducted measurement invariance on these two factors in the ASHSr. We hypothesized that males and females, and adolescents with a private room and those without, interpreted sleep hygiene in a similar way. Also, we examined concurrent validity via associating ASHSr with mental health and general health outcomes and known-group validity by comparing ASHSr and objective sleep measure (ie, actigraphy).

## 2. Methods

### 2.1. Participants and procedure

Participants were 389 adolescents aged 14–18 in sixteen high schools in Qazvin, the largest city (population: approximately 400,000) and capital of the Province of Qazvin in Iran. A two-stage cluster sampling strategy was used to recruit adolescents. In the first stage, 16 schools were selected randomly from 60 high schools in Qazvin. In the second stage, one class was randomly selected in each school. Inclusion criteria for participants were: 13–19 years of age and written, informed consent with the study protocol. Parents' consent was also obtained before adolescents participated in the study. The study was approved by the ethics committee of Qazvin University of Medical Sciences and followed standard procedures for the protection of human participants. Further approval was obtained from the Organization for Education at Qazvin.

### 2.2. Procedure

Adolescents and their parents were invited to attend an information session. A trained research assistant then described the study's aims to the adolescents and their parents. The trained research assistant assessed the adolescents regarding eligibility criteria for this study. The eligible adolescents and their parents were asked to provide written consent, and baseline questionnaires were provided to the adolescents to complete. After completion of their questionnaire, adolescents were supplied with a portable actigraphic device and were instructed that they would be wearing it for at least five days continuously for 24 h (three weekdays and two weekend days, ie, from Sat to Wed or from Thu to Mon). Two weeks later, the same adolescents were asked to redo the study's measures.

### 2.3. Translation procedure

A standard procedure was used to translate the English 24-item ASHSr into the Persian language [23,24]. The translation process took place in several stages. In the first stage, the English ASHSr was translated into the Persian language by two bilingual translators whose mother tongue was Persian (forward translation). The translated forms were synthesized into a merged Persian version by the two translators as well as a project manager. In the third step, the merged Persian version was then translated back into English by two native English translators. These translators worked independently and were not aware of the original English version of ASHSr. All translated versions in both forward and backward translations were then reviewed by an expert committee (psychologist, pediatrician, psychiatrist, psychometrician, and nurse) regarding their semantic, idiomatic, experiential and conceptual equivalencies. All changes were made to clarify for a better understanding. An interim Persian version was pretested on a sample

of adolescents ( $n = 57$ ; 34 boys). After completing the questionnaire, these adolescents were interviewed to assess what they thought about each item, its scoring as well as a guideline. The final version of the ASHSr was used on 389 adolescents to assess psychometric properties of the tool.

#### 2.4. Instruments

**The Adolescent Sleep Hygiene Revised Scale (ASHSr)** is a 24-item self-reported questionnaire that assesses sleep hygiene practice using a six-point Likert scale (Sample item: *I go to bed feeling hungry*). There are six domains in the ASHSr: Cognitive-Emotional (6 items), Behavioral Arousal (three items), Sleep Stability (three items), Daytime Sleep (two items), Physiological (five items), and Sleep Environment (five items). After reverse coding an item, a higher score of the ASHSr indicates better sleep hygiene. The internal consistency of the ASHSr ( $\alpha = 0.81$  for Cognitive-Emotional; 0.62 for Behavioral Arousal; 0.68 for Sleep Stability; 0.78 for Daytime Sleep; 0.60 for Physiological; and 0.61 for Sleep Environment; [18]) was fair to acceptable (ie,  $>0.6$ ; [25]).

**The Depression Anxiety Stress Scale (DASS)** is a 21-item self-reported questionnaire that assesses depression, anxiety, and stress (seven items for each emotional distress) using a four-point Likert scale. A higher score on the DASS indicates a higher level of depression, anxiety, or stress. The internal consistency of the DASS was satisfactory ( $\alpha = 0.84$  for depression; 0.91 for anxiety; 0.86 for stress; [26]). Moreover, the DASS has good concurrent validity: the DASS subscales are moderate to highly correlated to the Beck Depression Inventory ( $r = 0.57$  to  $0.70$ ; [27]).

**The General Health Questionnaire (GHQ)** is a 12-item self-reported questionnaire that assesses general health, especially psychological well-being, using a four-point Likert scale. A higher score on the GHQ indicates worse health. The internal consistency of the GHQ was good ( $\alpha = 0.87$ ; [28]). Moreover, the GHQ has good concurrent validity in that it is moderately correlated to the global quality of life ( $r = -0.56$ ; [28]).

**The Pediatric Daytime Sleepiness Scale (PDSS)** is an eight item self-reported questionnaire that assesses daytime sleepiness using a five-point Likert scale (sample item: *How often do you fall asleep or get drowsy during class periods?*). After reverse coding one item, a higher score on the PDSS indicates a greater level of sleepiness, and the internal consistency of the PDSS was good ( $\alpha = 0.81$  and  $0.80$ ; [29]). Moreover, the PDSS has good concurrent validity that it is significantly and negatively correlated to the time spent in bed ( $r = -0.21$ ; [30]).

**The Pittsburgh Sleep Quality Index (PSQI)** is a 19-item self-reported questionnaire that assesses sleep quality and disturbance using a four-point Likert scale (sample item: *During the past month, how often have you had trouble sleeping because you had bad dreams?*). A higher score of the PSQI indicates poorer sleep quality, and the internal consistency of the PSQI was good ( $\alpha = 0.77$ ; [31]). Moreover, the PSQI has good concurrent validity in that it is moderately correlated to the GHQ ( $r = 0.54$ ; [31]).

**The Sleep Disturbance Scale for Children (SDSC)** is a 27-item parent-rated questionnaire that assesses sleep quality of children/adolescents using a five-point Likert scale (sample item: *The child feels anxious or afraid when falling asleep*). A higher score of the SDSC indicates poorer sleep quality, and the internal consistency of the SDSC was acceptable ( $\alpha = 0.71$  and  $0.79$ ; [32]). Moreover, the SDSC has known-group concurrent validity in that it has the ability to distinguish children with and without sleep disorders ( $F = 132.26$ ;  $p < 0.001$ ; [32]).

**Wrist Actigraphy** is an objective measure used for assessing the sleep-related behavior. Wrist actigraphy (Ambulatory Monitoring, Inc. USA) has been extensively used to monitor sleep patterns or

rest/activity cycle in adolescents [33]. The actigraphy instrument is a small, portable device that provides valuable information on detecting absence of movement in adolescents during day and night. Movements patterns recorded in 1-min epochs were digitized using the Zero-crossing mode to a computer using Action-W software, version 2.6.9905 software from the same manufacturer [34]. The Sadeh algorithm was used to estimate information on sleep parameters [35]. Wear time validation was confirmed using the following criteria: wear time of four days at least for 10 h in a day [36].

Sleep duration was computed based on the total number of minutes defined as sleep while in the bed after lights off [37]. Sleep efficacy was estimated using the percentage of time in bed actually spent sleeping. Sleep onset was defined as the first three consecutive epochs of actigraphic sleep at the beginning of the scoring interval. Wake after sleep onset was defined as minutes of wake after sleep onset during the time-in-bed interval. Finally, sleep onset latency was estimated calculating the period elapsing between bedtime to the first epoch of actigraphic sleep. Despite these benefits, it is not enough to assess subjective experiences of sleep quality (eg, daytime sleepiness) in adolescents [38]. Therefore, it is recommended to use both objective and subjective measure of sleep.

#### 2.5. Data analysis

We analyzed the data using descriptive statistics for participant characteristics and two types of psychometric testing (classical test theory and Rasch analysis) for the ASHSr. Descriptive statistics were analyzed using SPSS (version 23) software; the classical test theory using MPLUS version 7.0 software (for CFA); the Rasch analysis using WINSTEPS 4.0.1 (Chicago, IL).

In classical test theory, we used factor loadings derived from CFA, a corrected item-total correlation, and test-retest reliability 2-week interval using an intraclass correlation coefficient (ICC) to examine the psychometric properties of the ASHSr at the item level. The acceptable cutoffs for the testing were  $>0.5$  for factor loadings,  $>0.4$  for corrected item-total correlation, and  $>0.7$  for test-retest reliability [26,39]. We used ceiling and floor effects, internal consistency using Cronbach's  $\alpha$ , composite reliability, average variance extracted, and standard error of measurement to examine the psychometric properties of the ASHSr at the domain level. The acceptable cutoffs for the testing were  $<20\%$  for ceiling/floor effects,  $>0.7$  for internal consistency,  $>0.6$  for composite reliability,  $>0.5$  for average variance extracted, and  $<SD/2$  for standard error of measurement [40–44]. In CFA, the recommended fit indices were comparative fit index (CFI) and Tucker–Lewis index (TLI)  $> 0.9$ ; root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR)  $< 0.08$ .

Moreover, we adopted multi-group CFA with three models to test the measurement invariance of the ASHSr at the structural level. The three models were [1] a configural model (a first-order ASHSr framework with all items loading on their corresponding latent concept) [2] a metric invariance model (a model based on the configural model to constrain all factor loadings to be equal across gender or living condition), and [3] a scalar invariance model (a model based on the metric invariance model to constrain all item intercepts being equal across gender or living condition). We compared the three models to test metric invariance and scalar invariance [45] using the following cutoffs to support measurement invariance:  $\Delta CFI > -0.01$ ,  $\Delta SRMR < 0.02$ , and  $\Delta RMSEA < 0.015$  [46,47]. We additionally constructed several regression models using the ASHSr as the dependent variable to test its concurrent validity. Each regression had two confounders (age and gender) and one of the following independent variables: depression, anxiety,

stress and general health. We anticipated a negative association between the ASHSr and the independent variables.

In the Rasch analyses, we used a partial credit model to report item difficulty using an interval unit (*logit*), to examine item validity, to test item and person separation reliability, and to examine the differential item functioning (DIF) items. We adopted an information-weighted fit statistic (infit) mean square (MnSq) and outlier-sensitive fit statistic (outfit) MnSq to test the item validity, and we adopted a recommended range between 0.5 and 1.5 [48]. Acceptable cutoffs for item and person reliability were  $>0.7$  [49], and an adequate cutoff for DIF was  $<0.5$  [50]. Specifically, the DIF in the Rasch models tests measurement invariance across gender or living condition at the item level, and the DIF clearly identifies which items are easier or harder in different subgroups to fulfill the item description [51].

## 2.6. Justification of sample size

Among the analyses we conducted, the most complicated were the CFA and Rasch analyses. Therefore, we used the two analyses to estimate and justify our sample size. In general, the literature suggests a sample size equal to or greater than 200 to reach a stable estimate [52–54]. Additionally, the rule of thumb using the ratio of  $n$  per variable for the CFA is 10 [55]. Given that the ASHSr has 24 items, the estimated preferred sample size is 240 based on the rule of thumb. Regarding the Rasch, the literature indicates that a Rasch model with a five-point Likert-scale can be reasonably estimated in 250 respondents [56,57]. Given that the ASHSr uses a six-point Likert-scale, we tentatively considered that our sample size should be more than 250. As a result, we believed that a sample size of more than 350 would be sufficient.

## 3. Results

The mean (SD) age of the 389 participants was 15.4 (1.1), and slightly more than half of them were males (51.2%). More than one-third of the participants (35.5%) were current smokers, and more than half of the participants (53.7%) owned a private room. The mean score was 7.9 (4.2) for depression, 8.7 (4.1) for anxiety and 7.6 (5.0) for stress (Table 1).

Table 2 presents the psychometric properties of the ASHSr at the item level. The factor loadings derived from the first-order CFA were acceptable or nearly acceptable (0.64–0.88), the corrected item-total correlations were satisfactory for all the items (0.70–0.92), and the test-retest reliability coefficients were excellent for all the items (0.72–0.90). Satisfactory psychometric findings at the item level were shown in the Rasch analyses: infit MnSq was between 0.73 and 1.30, and outfit MnSq was between 0.74 and 1.32. Only one item displayed substantial DIF (ie, DIF contrast =  $-0.52$  in item CE-5) across gender, and no items

displayed substantial DIF across living condition (ie, living in a private room or not).

Table 3 presents the psychometric properties of the ASHSr at the domain level. The results of classical test theory showed that both composite reliability (0.76–0.88) and average variance extracted (0.51–0.74) were adequate for all the ASHSr domains; the ceiling (1.3–3.6) and floor effects (0.8–4.9) were low to negligible, and the internal consistency (0.75–0.88) and standard error of measurement was acceptable (all were smaller than the SD/2 except for the Behavioral arousal domain which was slightly higher than SD/2: 0.40 vs. 0.395). The second-order CFA showed that the structure of ASHSr is supported (CFI = 0.965, TLI = 0.961, RMSEA = 0.049, SRMR = 0.040; Fig. 1). The separation reliability derived from the Rasch analysis also demonstrated good reliability for the ASHSr domains (person separation reliability = 0.77 to 0.84; item separation reliability = 0.73 to 0.97). The measurement invariance at the structural level indicated that males and females interpreted the ASHSr similarly ( $\Delta$ CFI =  $-0.006$  and  $-0.001$ ;  $\Delta$ SRMR = 0.001 and 0.006;  $\Delta$ RMSEA = 0.001 and 0.002). Those living in a private room and those not living in a private room also interpreted the ASHSr similarly ( $\Delta$ CFI =  $-0.001$  and  $-0.003$ ;  $\Delta$ SRMR = 0.020 and 0.001;  $\Delta$ RMSEA = 0.002 and 0.001; Table 4).

Also, concurrent validity and known-group validity of the ASHSr were also supported. In the concurrent validity, ASHSr total score was significantly and negatively correlated with depression ( $\beta = -0.30$ ;  $p < 0.001$ ), anxiety ( $\beta = -0.15$ ;  $p < 0.001$ ), stress ( $\beta = -0.42$ ;  $p < 0.001$ ), and general health ( $\beta = -0.66$ ;  $p < 0.001$ ) with substantial explained variance ( $\Delta R^2 = 0.05$  to  $0.33$ ; Table 5). In the known-group validity, both subjective (PDSS, PSQI, and SDSC scores) and objective measures (total sleep time, sleep efficiency, bedtime, wake time, sleep onset latency, and minutes awake between sleep onset and wake time derived from actigraphy) supported that ASHSr could differentiate between people with poor sleep hygiene and those with good hygiene (Table 6). Moreover, Table 7 demonstrates the correlation coefficients among the domains in the ASHSr.

## 4. Discussion

We translated the ASHSr into Persian and tested its psychometric properties using classical test theory and the Rasch model, in a sample of Iranian adolescents. It is the first study to examine the psychometric properties of ASHSr using a Rasch analysis. We found that the Persian ASHSr had a first-order six-factor structure which corresponds to the findings of Storfer-Isser et al., [18]. Moreover, we found that the ASHSr was measurement invariant across male and female adolescents and different living conditions (lived in a private room vs. not lived in a private room). Other psychometric properties found in the Persian ASHSr include nearly negligible floor and ceiling effects, excellent reliability (including composite reliability, internal consistency, separation reliability, and test-retest reliability), satisfactory concurrent validity (with depression, anxiety, stress, and psychological health), and supported known-group validity.

Storfer-Isser et al., and de Bruin et al., had concluded that the ASHS and ASHSr had promising psychometric properties [17,18]. Our results on ASHSr confirmed their findings, although de Bruin et al., only investigated the ASHS [17]. Moreover, we filled in a literature gap as both Storfer-Isser et al., and de Bruin et al., noted the lack of test-retest reliability information in ASHS and ASHSr [17,18]. Specifically, our test-retest reliability in a two-week interval (0.72–0.90) is in line with Chehri et al., : their test-retest reliability in a six-week interval is between 0.82 and 0.87 [10]. Therefore, the reproducibility of the Persian ASHSr is satisfactory in both the short-term and the long-term. Regarding internal

**Table 1**  
Participants characteristics (N = 389).

	Mean $\pm$ SD or n (%)
Age (Year)	15.4 $\pm$ 1.1
Gender (Male)	199 (51.2)
Fathers' educational year	7.9 $\pm$ 3.3
Mothers' educational year	6.5 $\pm$ 3.9
Currently smoker (Yes)	138 (35.5)
Living conditions: private room (yes)	209 (53.7)
Score in depression <sup>a</sup>	7.9 $\pm$ 4.2
Score in anxiety <sup>a</sup>	8.7 $\pm$ 4.1
Score in stress <sup>a</sup>	7.6 $\pm$ 5.0

<sup>a</sup> Measured using Depression Anxiety Stress Scale.



**Table 2**  
Psychometric properties of the Adolescent Sleep Hygiene Revised Scale (ASHSr) – item level.

Item#	Analyses from classical test theory			Analyses from Rasch				
	Factor loading <sup>a</sup>	Item-total correlation	Test-retest reliability <sup>b</sup>	Infit MnSq	Outfit MnSq	Difficulty	DIF contrast across gender <sup>c,d</sup>	DIF contrast across living condition <sup>c,e</sup>
CE-1	0.72	0.75	0.84	0.87	0.89	−1.34	0.15	0.06
CE-2	0.72	0.77	0.86	0.89	0.88	−1.14	−0.19	−0.32
CE-3	0.69	0.70	0.80	1.13	1.18	−0.70	−0.18	−0.43
CE-4	0.70	0.75	0.81	1.12	1.07	−1.58	−0.50	0.32
CE-5	0.76	0.73	0.84	1.00	0.99	−1.08	−0.52	0.13
CE-6	0.70	0.75	0.87	0.88	0.90	−1.14	0.01	−0.23
BA-1	0.70	0.80	0.79	1.22	1.23	−0.55	0.01	−0.33
BA-2	0.73	0.77	0.82	1.08	1.05	−0.15	−0.48	−0.39
BA-3	0.72	0.75	0.80	1.30	1.32	0.14	−0.20	0.07
SSt-1	0.85	0.74	0.90	1.13	1.15	−0.59	0.41	0.28
SSt-2	0.84	0.71	0.82	1.24	1.26	−0.50	0.23	−0.09
SSt-3	0.64	0.70	0.84	1.05	1.05	−0.51	0.36	0.35
DS-1	0.88	0.90	0.86	1.14	1.11	−0.02	0.34	−0.09
DS-2	0.84	0.92	0.89	1.25	1.26	−0.09	−0.15	0.17
Phy-1	0.61	0.73	0.82	0.93	0.98	1.04	−0.31	0.15
Phy-2	0.63	0.74	0.72	1.03	1.07	1.13	0.09	0.28
Phy-3	0.78	0.81	0.88	0.85	0.87	0.80	−0.40	−0.08
Phy-4	0.81	0.83	0.79	0.81	0.80	0.80	−0.23	0.12
Phy-5	0.74	0.78	0.86	0.77	0.81	0.69	−0.22	0.30
SEn-1	0.74	0.80	0.78	0.81	0.82	1.02	0.17	0.24
SEn-2	0.83	0.87	0.82	0.77	0.76	0.90	0.41	−0.24
SEn-3	0.78	0.83	0.89	0.81	0.79	1.15	0.30	−0.03
SEn-4	0.79	0.82	0.79	0.73	0.74	0.96	0.29	−0.11
SEn-5	0.73	0.80	0.87	0.83	0.83	0.76	0.38	−0.05

CE = Cognitive -Emotional, BA = Behavioral Arousal, SSt = Sleep Stability, DS = Daytime Sleep, Phy = Physiological, SEn = Sleep Environment, MnSq = mean square error; DIF = differential item functioning.

<sup>a</sup> Based on the first-order confirmatory factor analysis.

<sup>b</sup> Using Intraclass Correlation Coefficient (ICC).

<sup>c</sup> DIF contrast >0.5 indicates substantial DIF.

<sup>d</sup> DIF contrast across gender = Difficulty for females-Difficulty for males.

<sup>e</sup> DIF contrast across living condition = Difficulty for participants with private bedroom-Difficulty for participants without private bedroom.

consistency, our results are comparable to the findings from Iranian adolescents and are better than the findings from American and Italian adolescents [10,13,18]. Therefore, the ASHSr items are appropriate to use in Iran.

Storfer-Isser et al., also recommended that future studies reconfirm the factorial structure of the ASHSr [18]; our results on the ASHSr's construct validity, corresponding to the findings from Chehri et al., resolved their concerns: the factorial structure of the ASHSr was confirmed by the CFA conducted by Chehri et al. and us [10]. It is noteworthy that the factor loadings in our results were all satisfactory, while Chehri et al., reported three unsatisfactory factor loadings [10]. Furthermore, we used Rasch models to reconfirm the factorial structure and to ensure that every item fits in its embedded construct. In addition to the concerns of test-retest reliability and construct validity, our other results revealed that the ASHSr had strong psychometric properties, including measurement invariance across gender and living condition as well as the ability to distinguish adolescents

with poor sleep hygiene behaviors from those with good behaviors.

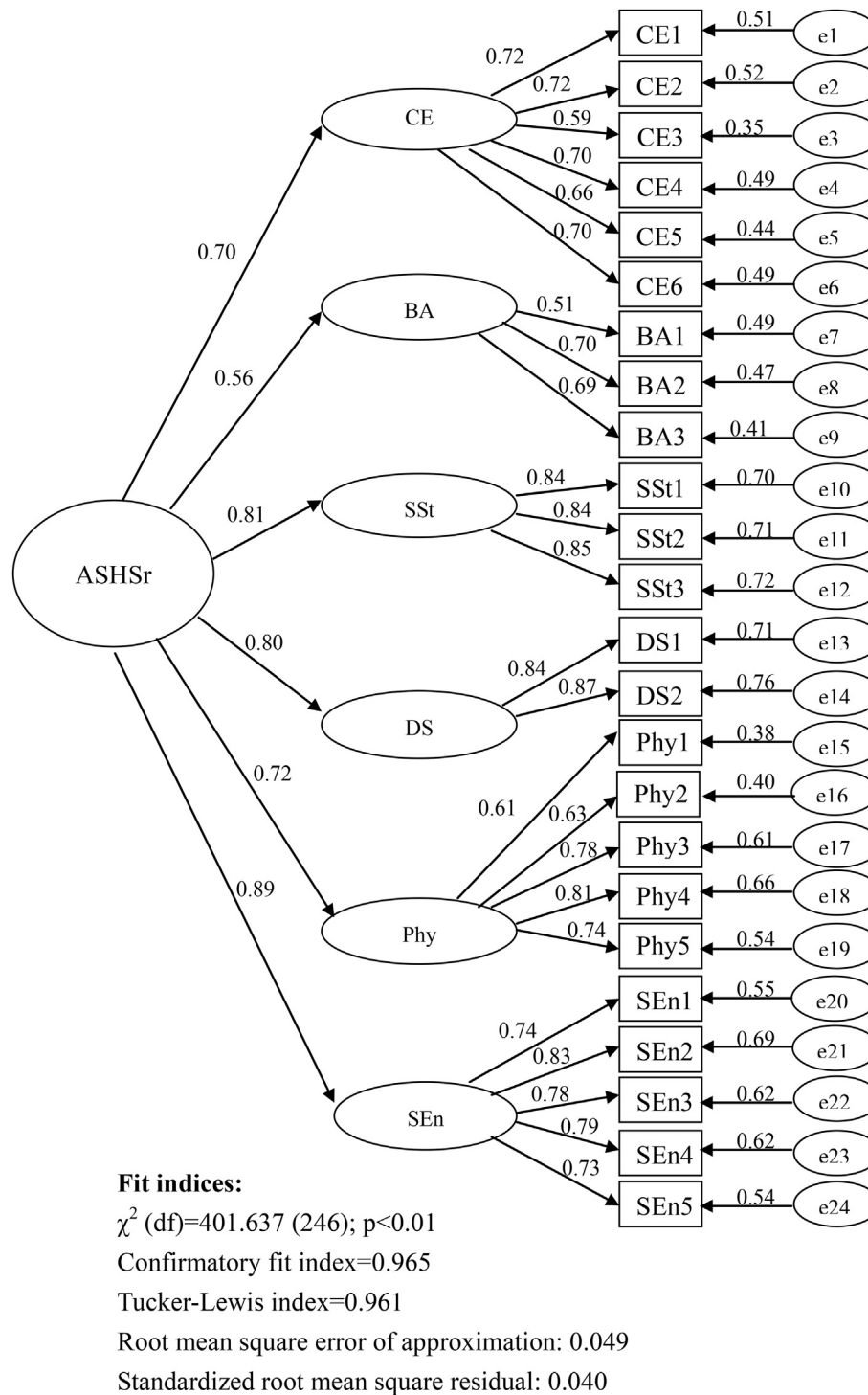
Because of the strong psychometric properties of ASHSr shown in our results, we are confident to recommend that healthcare providers use the ASHSr to assess (or monitor) sleep hygiene behaviors in adolescents. Regularly assessing sleep hygiene in adolescents may help healthcare providers design appropriate programs to improve their sleep quality, given the strong association that has been found between ASHS and sleep quality [12]. Moreover, healthcare providers can use any change of ASHSr scores to identify easily whether their programs are effective or not.

Our study has two major strengths. First, we tested the psychometric properties of the ASHSr using both classical test theory and Rasch models. The major benefit of using classical test theory is that most of the healthcare providers are familiar with this method, and have little difficulty in interpreting the results derived from it [58]. On the other hand, the Rasch model has several well-known

**Table 3**  
Psychometric properties of the Adolescent Sleep Hygiene Revised Scale (ASHSr) – domain level.

Psychometric testing	CE	BA	SSt	DS	Phy	SEn
Composite reliability	0.84	0.76	0.88	0.85	0.84	0.87
Average variance extracted	0.51	0.51	0.71	0.74	0.52	0.57
Ceiling effects (%)	2.3	3.1	3.6	2.6	1.5	1.3
Floor effects (%)	1.3	0.8	2.1	2.8	2.3	4.9
Internal consistency (Cronbach's $\alpha$ )	0.84	0.75	0.88	0.85	0.83	0.88
Person separation reliability	0.77	0.77	0.84	0.80	0.78	0.77
Item separation reliability	0.96	0.97	0.76	0.73	0.92	0.88
Standard error of measurement	0.24	0.40	0.36	0.44	0.31	0.32
Mean (SD)	3.99 (0.66)	3.38 (0.79)	3.62 (1.05)	3.30 (1.14)	2.62 (0.77)	2.57 (0.88)

CE = Cognitive -Emotional, BA = Behavioral Arousal, SSt = Sleep Stability, DS = Daytime Sleep, Phy = Physiological, SEn = Sleep Environment.



**Fig. 1.** Second-order factor loadings from the 6-factor Model Adolescent Sleep Hygiene Revised Scale (ASHSr). CE = Cognitive-Emotional, BA = Behavioral Arousal, SSt = Sleep Stability, DS = Daytime, Sleep, Phy = Physiological, SEn = Sleep Environment.

advantages. It converts the ordinal scale (eg, Likert type scale) into an interval scale with the unit of *logit*. Further, it estimates the reliability separately for item and respondents; therefore, the reliability information is not dependent on the sample. It also tests measurement invariance (ie, DIF) in item level; therefore, it is possible to easily identify which item is not invariant across subgroups [49]. As we adopted both methods under different testing theories to tackle the psychometric properties of the ASHSr, we are

confident that we provide comprehensive and robust results to fully demonstrate the ASHSr's properties.

The second strength of this study is that we used both objective and subjective measures to assess sleep and applied both measures to investigate the known-group validity of the ASHSr. Because the use of actigraphy for assessing sleep outcomes and its validity has been well established [37,59], our actigraphy data validated the psychometric properties of the ASHSr. Moreover, actigraphy

**Table 4**

Measurement invariance across gender and across living condition on Adolescent Sleep Hygiene Revised Scale (ASHSr) using confirmatory factor analysis.

Model and comparisons	Fit statistics							
	$\chi^2$ (df)	$\Delta\chi^2$ ( $\Delta$ df)	CFI	$\Delta$ CFI	SRMR	$\Delta$ SRMR	RMSEA	$\Delta$ RMSEA
<b>Gender</b>								
M1: Configural	673.15 (474)*		0.961		0.055		0.030	
M2: Plus all loadings constrained	685.41 (498)*		0.955		0.056		0.031	
M3: Plus all intercepts constrained	705.11 (532)*		0.954		0.062		0.033	
M2–M1		12.41 (24)		–0.006		0.001		0.001
M3–M2		19.59 (34)		–0.001		0.006		0.002
<b>Living condition on ASHSr</b>								
M1: Configural	642.12 (474)*		0.963		0.055		0.030	
M2: Plus all loadings constrained	669.35 (498)*		0.962		0.075		0.032	
M3: Plus all intercepts constrained	713.01 (532)*		0.959		0.076		0.033	
M2–M1		27.23 (24)		–0.001		0.020		0.002
M3–M2		43.66 (34)		–0.003		0.001		0.001

\*p&lt;0.05.

M1 = Model 1, a configural model; M2 = Model 2, a model based on M1 with all factor loadings constrained being equal across groups; M3 = Model 3, a model based on M2 with all item intercepts constrained being equal across groups.

CFI = comparative fit index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation.

**Table 5**

Concurrent validity of the Adolescent Sleep Hygiene Revised Scale (ASHSr) using regression models with adjustment for age and gender.

Criterion	$\beta$ (p-value)	$\Delta R^2$	Overall $R^2$ (Adjusted $R^2$ )
Depression <sup>a</sup>	–0.30 (<0.001)	0.11	0.30 (0.29)
Anxiety <sup>a</sup>	–0.15 (<0.001)	0.05	0.30 (0.29)
Stress <sup>a</sup>	–0.42 (<0.001)	0.15	0.57 (0.56)
General Health Questionnaire	–0.66 (<0.001)	0.33	0.51 (0.51)

 $\Delta R^2$  = overall  $R^2$  – the  $R^2$  derived from age and gender; that is, indicating the explained variance of the criterion.<sup>a</sup> Depression, anxiety, and stress were measured using the Depression Anxiety Stress Scale.

provided critical information (eg, sleep quality) related to sleep hygiene behaviors. Although such critical information can be measured using subjective measures (eg, the PDSS, PSQI, and SDSC used in our study), objective measures such as actigraphy prevent the respondents from recall and social desirability bias. The literature has well documented the validation of wrist actigraphy regarding the estimation of nighttime sleep parameters across age groups.

Moreover, current practice in clinical guidelines and research prefers using wrist actigraphy because it documents sleep patterns and evaluates circadian rhythm sleep disorders. Therefore, wrist actigraphy can provide objective information to evaluate treatment outcomes, such as monitoring of sleep-disordered breathing at home [33]. Of note, however, that participants could forget to wear

**Table 6**

Known groups validity testing: Comparison of ASHSr Scores as a function of objective sleep measure (Actigraphy), Pediatric Daytime Sleepiness Scale (PDSS), Pittsburgh Sleep Quality Index (PSQI), and Sleep Disturbance Scale for Children (SDSC).

	Very Poor sleep hygiene N = 71 <sup>a</sup>	Poor sleep hygiene N = 112 <sup>a</sup>	Good sleep hygiene N = 146 <sup>a</sup>	Very Good sleep hygiene N = 60 <sup>a</sup>	F (P-value)	$\eta p^2$
Total sleep time (minutes)* M $\pm$ SD <sup>b</sup>	412.1 $\pm$ 9 <sup>b</sup>	423.65 $\pm$ 93	441 $\pm$ 88	457 $\pm$ 82	24.02 (<0.001)	0.06
Sleep efficacy (%) <sup>c</sup> M (95% CI) <sup>b,c</sup>	91.3 (89.8, 94.1)	92.1 (90.0, 95.1)	92.9 (90.8, 95.6)	93.8 (91.1, 95.6)	10.58 (0.001)	0.03
Bedtime (hour.minute)* M (95% CI) <sup>b</sup>	00.45 (23.31, 1.38)	00.40 (23.1 <sup>b</sup> , 1.27)	00.05 (23.04, 1.10)	23.11 (22.54, 00.32)	6.55 (<0.001)	0.08
Wake time (hour.minute)* M (95% CI) <sup>b</sup>	7.28 (6.50, 7.59)	7.30 (6.43, 7.55)	7.26 ( <sup>b</sup> 5.8, 7.49)	7.22 (6.42, 7.38)	4.81 (<0.001)	0.06
Sleep onset latency (minute)* M (95% CI) <sup>b</sup>	22.2 (10.2, 33.7)	20.6 (13.4, 34.2)	18.7 (11.6, 35.2)	13.3 (9.2, 23.5)	21.52 (<0.001)	0.05
Wake after sleep onset (minute)* M (95% CI) <sup>b,d</sup>	18.3 (11.7, 23.1)	18.0 (12.0, 35.2)	16.4 (7.9, 26.2)	12.1 (7.2, 20.2)	18.65 (<0.001)	0.05
PDSS (Likert scale)* M $\pm$ SD	11.3 $\pm$ 4.9	10.9 $\pm$ 5.3	9.5 $\pm$ 4.2	8.6 $\pm$ 4.3	10.44 (0.001)	0.03
PSQI (Likert scale)* M $\pm$ SD	6.2 $\pm$ 2.0	6.0 $\pm$ 2.1	5.6 $\pm$ 2.0	5.3 $\pm$ 1.9	6.45 (0.011)	0.02
SDSC (Likert scale)* M $\pm$ SD	60.1 $\pm$ 9.7	58.6 $\pm$ 10.2	55.4 $\pm$ 8.7	51 $\pm$ 10.4	17.45 (<0.001)	0.04

\*Statistically significant according to Benjamini–Hochberg procedure for Sleep hygiene. ASHSr = Adolescent Sleep Hygiene Revised Scale. SDSC was reported by parents.

 $\eta p^2$  = partial eta squared: effect size with 0.010, 0.050, and 0.140 indicating small, medium, and large effect sizes.<sup>a</sup> Very poor sleep hygiene: total ASHSr score lower than 3.8 (the lowest quintile); Poor sleep hygiene: total ASHSr score between 3.8 and 4.4 (the second quintile); Good sleep hygiene: total ASHSr score between 4.4 and 4.9 (the second quintile); Very Good sleep hygiene: total ASHSr score higher than 4.9 (the highest quintile).<sup>b</sup> Measured using Wrist actigraphy.<sup>c</sup> Percentage of time asleep while in bed from lights off to lights on.<sup>d</sup> Minutes awake between sleep onset and wake time.

**Table 7**

Inter-correlations between the domains of the Persian Adolescent Sleep Hygiene Scale revised version (ASHSr).

	BA	SSt	DS	Phy	SEn
CE	0.42	0.50	0.46	0.44	0.50
BA	1	0.37	0.40	0.30	0.40
SSt		1	0.60	0.50	0.62
DS			1	0.45	0.62
Phy				1	0.63

All p-values <0.01.

CE = Cognitive -Emotional, BA = Behavioral Arousal, SSt = Sleep Stability, DS = Daytime Sleep, Phy = Physiological, SEn = Sleep Environment.

the wrist actigraphy. Also note, that psychometric information regarding the sleep-onset latency and daytime sleeping is lacking [33]. Furthermore, actigraphy may have questionable validity in special populations, including those who have poor sleep or other sleep-related disorders [60]. Another problem with actigraphy is its low specificity in detecting wakefulness within sleep periods [60]. Therefore, the combined use of objective and subjective measures provides maximum information about sleep quality.

There are several limitations in this study. First, we only recruited Iranian adolescents. Therefore, our results may not be generalizable to other ethnicities or other age groups. Second, we did not assess the personality traits of our participants, which means that we cannot ascertain whether adolescents with different personality traits interpret the ASHSr in a similar manner. As personality traits have been found to be related to sleep hygiene behaviors [61], future studies may want to investigate whether measurement invariance is supported for adolescents with different personality traits. Third, the sample was collected from the community, potentially restricting the ability to generalize our results to those who had already been diagnosed with sleeping problems (eg, insomnia).

## 5. Conclusion

In conclusion, we demonstrated the validity of the Persian ASHSr in an Iranian adolescent sample. The construct of the ASHSr was supported by both CFA and Rasch models. Concurrent validity was satisfactory as associations were found between the ASHSr and other psychological factors. Known group validity was excellent; those who had poor sleep hygiene revealed worse sleep, as shown by both objective and subjective measures, than those who had good sleep hygiene. The Persian ASHSr is an appropriate instrument for healthcare providers to routinely assess the sleep hygiene of adolescents.

## Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: <https://doi.org/10.1016/j.sleep.2018.05.036>.

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